PHASE EQUILIBRIA

(A) Descriptive Questions

- 1. Briefly discuss a method of determining the vapour pressure of a liquid over a range of temperatures. Explain how you would treat the data obtained to determine the heat of vaporisation (ΔH_{vap}) of the liquid.
- 2. (a) What is the significance of the triple point of a substance?
 - (b) Explain why solid carbon dioxide sublimes under normal room temperature conditions, whereas ice melts.
 - (c) Explain the principles and techniques involved in the process of "freeze-drying".
- 3. What is an ideal solution?
- 4. Explain the physical chemistry principles and experimental procedures involved in steam distillation.
- 5. Ethanol (normal b.p. 78°C) and water form a minimum boiling point mixture which is rich in alcohol. Sketch and label a temperature composition diagram for this system and use it to predict what separation of components would be achieved if a dilute solution of alcohol in water is distilled up an efficient fractionation column.

(B) Calculations

- 1. Calculate the temperature at which *n*-butanol will boil at a pressure of 2666.4 Pa, if the normal boiling point is 118° C. Δ H_{vap} (*n*-butanol) = 44.5 kJ mol⁻¹.
- 2. The vapour pressure of *n*-butane is 3.41 x 10^5 Pa at 30° C and 8.95 x 10^5 Pa at 70° C. Calculate ΔH_{vap} (*n*-butane) in this temperature range.
- 3. At 30°C benzene and toluene have vapour pressures in the pure state of 119.6 torr and 36.7 torr, respectively.

(a) What are the partial vapour pressures of each of these compounds and the total pressure over a solution consisting of equal weights of these two components at 30° C?

(b) What is the composition of the vapour in equilibrium with the solution at this temperature?

(Assume ideal behaviour: benzene = C_6H_6 , toluene = $C_6H_5CH_3$.)

- 4. The **distribution ratio** describes the ratio (g/g) of a solute that is found in each layer of a 2 solvent system. The distribution ratio for aniline between benzene and water is 10.0 at 298 K.
 - a) A solution of 1.000 g of aniline in 1000 cm³ of water is equilibrated with 500 cm³ of benzene. How much aniline remains in the aqueous phase?

- b) If the same aqueous solution of aniline (1.000 g in 1000 cm³) was successively equilibrated with two separate 250 cm³ portions of benzene, how much aniline would then be left in the aqueous phase?
 (NB: Aniline is C₆H₅NH₂)
- 5. Chlorobenzene distils with steam at 91[°]C when the external pressure in 1 atm. At this temperature its vapour pressure is 214 torr. Calculate the quantity of water that would have to be distilled to effect the purification of 10 grams of this compound.

COLLOIDS

(A) Descriptive Questions

- 1. What do you understand by the following?
 - (a) Colloid
 - (b) Emulsion
 - (c) Gel
 - (d) Foam
 - (e) Lyophobic Colloid
 - (f) Electrical Double Layer
- 2. Explain why Lyophobic Colloids are described as thermodynamically unstable and yet, in the absence of moderate to large concentrations of electrolytes, sedimentation of particles is often not observed over long periods of time, e.g. weeks.
- 3. Briefly discuss, with explanation, the effects on lyophobic colloids of the addition of
 - (a) electrolytes;
 - (b) polymer solutions.

MOLECULAR ORBITAL THEORY

(A) Descriptive Questions

- 1. What do you understand by the following?
 - (a) Hund's rule as applied to Molecular Orbitals
 - (b) The Linear Combination of Atomic Orbitals (LCAO) approximation
 - (c) The *bond order* of a diatomic molecule

1. The following MO scheme is appropriate for homonuclear diatomic molecules.



Calculate the bond orders and predict the stability of C_2 , C_2^- , O_2 , O_2^+ using the above MO scheme.

Which of these molecules would be expected to display paramagnetic behaviour?

NUMERIC ANSWERS

PHASE EQUILIBRIA

Answers:

- **1.** 36°C;
- 2. 20.8 kJ / mol;
- **3.** p_{benz} 64.7 , $p_{\text{tol}}16.8,\,p_{\text{total}}$ 81.5 torr; x_{benz} 0.79, x_{tol} 0.21 ;
- **4.** (a) 0.167g, (b) 0.082g;
- **5.** 4.1g